DOCUMENT RESUME

ED 362 213 IR 016 369

AUTHOR Wilson, Brent G.
TITLE Constructivism and Instructional Design: Some Personal Reflections.
PUB DATE Jan 93
NOTE 20p.; In: Proceedings of Selected Research and Development Presentations at the Convention of the Association for Educational Communications and Technology Sponsored by the Research and Theory Division (15th, New Orleans, Louisiana, January 13-17, 1993); see IR 016 300.
PUB TYPE Information Analyses (070) -- Viewpoints (Opinion/Position Papers, Essays, etc.) (120) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Behaviorism; *Constructivism (Learning); *Curriculum Design; Educational Philosophy; Educati search; *Educational Theories; Elementary Secon Education; Heuristics; Higher Educatior., *Instructional Design; Learning; Teaching Methods; *Theory Practice Relationship
IDENTIFIERS *Positivism

ABSTRACT

Some personal reflections on instructional design and its relation to constructivism are explored. Instructional design in its present form is out of sync with the times in that its orientation, methods, and research base are behavioristic, or positivistic. However, a constructivist theory of instructional design is possible, particularly if constructivism is recognized as a philosophy rather than a strategy. To better fit the needs of practitioners, instructional design theories need to be better grounded in a broad understanding of learning and instructional processes. Generic principles and specific heuristics are needed for dealing with recurring problems and situations in instructional design practice. In addition, instructional design theories need to reflect instructional design as a profession. The theories of instructional design need to be adjusted or replaced with better ones that fit the newer understandings of learning and instruction. (Contains 81 references.) (SLD)

Title:

Constructivism and Instructional Design: Some Personal Reflections

Author:

Brent G. Wilson

Constructivism and Instructional Design: Some Personal Reflections

Brent G. Wilson
University of Colorado at Denver

The field of instructional design (ID) is in a state of rapid change. Recent expressions of constructivist theorists (Bednar, Cunningham, Duffy, & Perry, 1991) have engendered a lively debate, reflected in the May and September 1991 issues of *Educational Technology* magazine and the winter 1992 issue of *ETR&D*. If our IT department is any indication, graduate students across the nation are engaging their professors in heated discussions concerning the fundamental models in our field, and how they hold up to the constructivist onslaught.

This is good. I feel better about the future of ID than I have since I was a graduate student myself. For years, Dave Merrill has pled that more serious attention be given to ID theory development. He finally seems to be getting his wish, but perhaps not the result he anticipated. For a long time, thoughts about the nature of ID theory and its practice have been fermenting in my mind; this paper is my forum for airing some of those thoughts and sharing them with a wider audience. The tone is personal because it deals with underlying assumptions I have made in doing ID. In a way, the paper is a sort of confessional—my tone and stance are much less temperate than any of my previous writing. Narrative forms of research are recently gaining esteem among educators and social scientists (Polkinghorne, 1988; Connelly & Clandinin, 1990; Witherell & Noddings, 1991); I ask you to consider this paper a sort of narrative documentation of my professional beliefs about ID.

The Problem: ID Is Out of Sync

The problem can be simply stated: ID, in its present form, is out of sync with the times.

- Its orientation is behavioristic.
- Its methods are behavioristic.
- Its research base is behavioristic.

I know that these claims make some people mad, particularly people who believe we have completed the "cognitive revolution." They are generalizations, and admittedly there are exceptions. Perhaps a better descriptor would be 'positivistic' rather than 'behavioristic.' But the image of ID to outsiders is definitely behavioristic. Survey any group of faculty within a college of ed; you will find a stereotyped impression of ID as no-nonsense, results-driven behaviorism applied to education. A similar image holds among educational researchers: members of the IT SIG group within AERA tend to be seen as positivists *par excellence*.

To most of us, this comes as no surprise. To some, our positivistic/ behavioristic bias is not a problem. In the current zeitgeist of increasing constructivism, however, behavioristic notions of ID find themselves increasingly out of the mainstream of educational thought. I wonder, prior to the *Ed Tech* issues, how many ID grad students had really confronted the disparity between progressive educational thought and the ID models learned in classes. To many, the *Ed Tech* issues must have contributed to a loss of innocence. The line is now clearly drawn, and I suspect many find themselves uncomfortable as they see unwanted conceptual baggage accompanying the tools and models of their field.

It is possible, though, that I am merely projecting my own past perceptions and experiences onto others. As a graduate student, I felt privileged to have worked

closely with David Merrill and Charles Reigeluth at Brigham Young University, particularly in the development of elaboration theory (Reigeluth, Merrill, Wilson, & Spiller, 1980). I bought into the field—its theories, models, and aims—yet I always felt an ambivalence toward what I perceived as cut-and-dried design prescriptions in areas that I felt so personally "mushy" about. My respect for the complexity and difficulty of design decisions always made me hesitant about explicit, canned procedures and models that were meant to answer all the questions. I felt that ID lacked a sense of perspective or a sense of modesty toward the awesome task of meeting people's learning needs. Recently I came across some old notes I had made, dated 15 March 1978, titled "Issues that still haven't been resolved in SSDP (Structural Strategy Diagnostic Profile—the old name for elaboration theory). Excerpts of those notes are reproduced in Table 1. Re-reading those notes reminded me that many of the issues are still pertinent to today's discussion, including the nature of knowledge and content, the role of context, parts versus wholes, and accommodation of alternative structures. The task of adapting ID theories to address these issues still remains.

In the ID articles I have written since then, I have tried to steer a delicate balance between being too accepting of the "received view" about ID and being too radical. I did not want to lose my audience. My moderate tone belied the urge within to shout, "Wait—don't you see? We've got it wrong!" That urge was heightened by the recent comments of an anonymous IT/SIG reviewer on a paper critiquing elaboration theory (Wilson & Cole, 1992):

> You have put your finger on a fundamental difference in approaches taken by those who believe that instruction can be designed to teach knowledge and those who believe that knowledge is constructed by learners....I would go so far to say that the two positions are irreconcilable. If you accept what the "humanistic theorists" say, then you cannot simply revise [elaboration theory] in the ways you propose to make it fit in with these views. You have to throw it out entirely!

I'm not as pessimistic about the possibility of reconciliation. *In fact, that is a major theme of this paper, that there can be a constructivist theory of instructional design.* But I am coming to believe that the best way to handle differences is not to be coy, not to downplay problems, but to be unflinchingly honest and straightforward in criticism, and aggressive in offering alternative design concepts. My experience has now started me wondering how many other professionals who, rather than confront their problems with the models, have simply walked away from the problem by disengaging themselves from the models or from the field.

On the Objectivist/Constructivist Debate

A few things have bothered me about the objectivist/constructivist dialogue. Rather than comprehensively examine the issue, I want to raise a few points.

1. ***You don't have to be a philosopher to take a position.*** Among the *Ed Tech* contributors, Perkins and Cunningham have considerable training in philosophy, but to my knowledge the remaining writers are, like you and me, relative novices in that domain. Our interest in these issues derives from a desire to do the right thing, to be knowledgeable about sources of bias and damaging assumptions we can make in our work. I hope that practitioners and researchers do not defer to the "experts" on issues so central to defining the field. At the same time, I am busy trying to expand my breadth and knowledge base about philosophy. As I read more Schön, more Bruner, and more postmodern philosophy, my perspective toward ID is necessarily influenced. That change in perception is for the good; I like the feeling that I am growing in understanding the meaning of my field. (And I confess I tend to grow impatient with fellow researchers who show no inclination to broaden their understanding of the issues squarely facing the field.)

How do our ideas of structure relate to learning/ memory theorists' ideas about how memory is organized? Mayer, Greeno, Ausubel, Kintsch, Craik & Tulving, Norman & Lindsey, Quillian & Collins, McConkie, etc....

The problem of "segmentation": Are we sure the contents of a discipline can be broken down into individual concepts, principles, etc.? What about what theorists call "verbal information," "meaningful verbal materials"—facts that are important to know but don't connect to any principles directly....Are we rather talking about a mere skeleton in our work, which, to be complete, needs to be fleshed out by facts, details, context, etc.?....

It seems to me that there are certain kinds of content whose purposes do not admit to use of synthesizers/epitomes on an elaborative approach. Narratives, for example, often have a dramatic component, as if the teacher/author were telling a story. It would be senseless to let the cat out of the bag prematurely simply to "stabilize" the content for the learner. An effective alternative (in certain situations) is having the student on the edge of his seat waiting in suspense for what happens next....

Bruner (1966) distinguishes between passive and active learning, between what we know and what we do with what we know. How do these seemingly separable kinds of knowledge relate to our scheme? Is true active learning on the rule-finding or rule-using level? Are procedures and principles real problem-solving behaviors? Would Ausubel object that we devalue facts and verbal information unnecessarily?....

Is 'content' defined as "What is," "What is presented to the student," or "What is expected to be learned?"

Table 1. Excerpts from my notes on elaboration theory, circa 1978.

2. ***Nobody I know admits to being an objectivist.*** Molenda (1991) points out that objectivism is primarily a pejorative label given by constructivists to the offending others (Johnson, 1984; Lakoff, 1987; Bruner, 1986). That fact alone is enough cause to worry. It's hard to talk seriously about a philosophical position that no one admits to. This goes for caricatures made by both ideological sides of the *Ed Tech* dialogues. Very few people hold radical positions of either persuasion.

Please note that my complaint has to do with labels and descriptions; many people may not call themselves objectivists, but their way of seeing may be very different from a constructivist perspective. Philosophers holding this more traditional view of the world call themselves *realists* (House, 1991; H. Putnum, 1990). To my understanding, realists do believe there is a "reality" out there, and that the quality of mental representations can be judged by their correspondence to that reality. This "correspondence theory of truth" is one of many issues hotly debated by philosophers. If they can disagree about it, I imagine the rest of us can as well.

The cross-talking going back and forth about constructivism reminds me of an anecdote I recently read in *Readers Digest* (Safire, 1991) about a Florida politician, asked to take a position on a county option to permit the sale of liquor:

> "If by *whiskey*, you mean the water of life that cheers men's souls, that smooths out the tensions of the day, that gives gentle perspective to one's view of life, then put my name on the list of the fervent wets.
>
> "But if by *whiskey*, you mean the devil's bew that rends families, destroys careers and ruin's one's ability to work, then count me in the ranks of the dries." (p. 14)

If by constructivism you mean the solipsism and subjectivism portrayed by Merrill or Molenda, then I am a strident opponent. But if by constructivism you refer to the reasoned, persuasive philosophy of a Cunningham or a Perkins, then count me in as a constructivist.

3. ***Neither side is right.*** I am suspicious of simple dichotomies like the idea that reality is either inside or outside of the mind. The analogy implicit in such claims is that the mind is like a box (Heideggar, 1984; Faulconer & Williams, 1990). Inside the box are reflections of what lies outside. Martin Heideggar's ontology rejects the box metaphor of mind, and the inner/outer dualism that goes with it (see Faulconer & Williams, 1990; Dreyfus, 1991; Winograd & Flores, 1986).

> Rather than accepting the metaphor of the box, with the human subject walled off from the nonhuman, objective world, Heideggar's analysis leads to the conclusion that human being is already being-in-the-world. There is no inside walled off from the outside. (Faulconer & Williams, p. 46)

According to Heideggar and other phenomenological philosophers, the starting point is recognizing that we simply are in the world, working, acting, doing things. Turning Descartes' famous maxim on its head, the motto becomes "*I am* [in the world]; *therefore I think.*"

On this view, individual cognition is dethroned as the center of the universe and placed back into the context of being part of the world. This philosophy is reminiscent of the socially oriented, connected ways of knowing found among women by Belencky and colleagues (Belencky, Clincy, Goldberger, & Tarule, 1986). I am attracted to such holistic conceptions of the world, even if my understanding of the philosophy is still incomplete (see Polkinghorne, 1990 for a good, short introduction to many of the issues). My reading is enough to make me suspect that much of the objective/constructive debate is based on the wrong questions.

4. ***Constructivism is a philosophy not a strategy.*** I reject the idea that a particular instructional strategy is inherently constructivistic or objectivistic. Constructivism is not an instructional strategy to be deployed under appropriate conditions. Rather, constructivism is an underlying philosophy or way of seeing the world. This way of seeing the world includes notions about:

- the nature of ***reality*** (mental representations have "real" ontological status just as the "world out there" does)
- the nature of ***knowledge*** (it's individually constructed; it is inside people's minds, not "out there")
- the nature of ***human interaction*** (we rely on shared or "negotiated" meanings, better thought of as cooperative than authoritative or manipulative in nature)
- the nature of ***science*** (it is a meaning-making activity with the biases and filters accompanying any human activity)

When we see the world in constructivist terms, we go about our jobs in a different way, but the difference cannot be reduced to a discrete set of rules or techniques. Let me give an example.

My son Joel recently turned eight, and for his birthday we presented him with a computer math drill-game. He is a good math problem-solver—he likes to play with numbers and invent routines —but because of a schooling mixup, he is behind in mastering his math facts. I essentially said, "Joel, this is a fun game you will enjoy; it will also help you learn the addition and subtraction skills that you're a little behind in. It's no big deal. You will be glad, because learning that stuff is something you want too."

Does my gift of a drill-and-practice program make me an objectivist? I deny that it does. I also deny that I am violating my deeply held constructivist principles about people and the way we learn. People do construct meaning from their experiences; learning should be meaningful and derive from an authentic context; people should be allowed to pursue individual learning goals. I believe that Joel has a pretty good idea of what the game is doing for him, and the kind of fun he is deriving from it. As he chooses to make use of the game, he *is* actively constructing meaning and new knowledge. Joel has plenty of other opportunities to exercise his more creative talents; his use of the game is filling a needed learning gap to meet

the expectations and pace set by his school. He was much happier in school two weeks later, when he aced the timed math test and came home to tell us about it.

My point is that a given instructional strategy takes on meaning as it is used, in a particular context. If I had tricked my son, "Joel, look at this computer game. It's better than Nintendo!" and pretended that he was already great at his math facts, and that the game had no bearing on his schooling, then I would have felt in violation of my philosophy. So the same instructional technique could have vastly different meaning (and effects) depending on its context of use.

Another example—a journal entry from Scott, a teacher in my *Reflective Educator* class last semester:

> Third hour composition I went to a seating chart, the first time I've done that here. I caught them as they came in and told them where to sit. Great improvement. Everyone working hard on their papers....I sense the students are relieved that I've imposed more structure.

Scott teaches at an alternative high school. His philosophy, as expressed in journal entries, class contributions, and teaching methods, is definitely constructivistic and anti-authoritarian. Yet imposing a seating chart on a class is a clear act of asserting authoritative control and imposing structure. Is Scott betraying his principles, or can an ostensibly "constructivist" instructional technique actually serve his constructivist learning and teaching goals? The students' answer to that is clear: they welcome the new arrangement and view it as supporting their own learning goals.

Too often, constructivism is equated with low structure and permissiveness—imposing predefined learning goals or a learning method is somehow interfering with students' construction of meaning. In extreme cases, that may be true. Yet to help students become creative, some kind of discipline and structure must be provided. Laurel (1991) cites Rollo May (1975), who makes this point very well:

> Creativity arises out of the tension between spontaneity and limitations, the latter (like river banks) forcing the spontaneity into the various forms which are essential to the work of art....The significance of limits in art is seen most clearly when we consider the question of form. Form provides the essential boundaries and structure for the creative act. (quoted in Laurel, 1991, p. 101)

In other words, an instructional strategy that imposes structure may actually help learners make constructions needed for learning. Joel's computer game or Scott's seating chart may be hindering or serving constructivist learning goals: You can't tell by looking only at the strategy; you have to look at the entire situation and make a judgment. That is the role of the teacher or instructional designer: to make professional judgments about such things.

Implications for Design Theories[1]

In this section, I turn to the more difficult issue of defining ID theories and their relation to practice.

---

[1]Some may object to the use of the term 'theory' when applied to instructional design, arguing these alleged theories are really nothing more than technological models. I retain Reigeluth's (1983a) use of 'theory' for two reasons: (1) to distinguish between ID theories and instructional development models that prescribe a methodology for managing ID projects (cf. Andrews & Goodson, 1980), and (2) because philosophers of science liberally apply the terms 'theory' and 'model' to a variety of frameworks of varying complexity, formality, and power (Suppe, 1977).

What is Instructional-Design Theory?

Traditionally, ID theories are seen as *prescriptive* in the the sense that

- they provide recipes or heuristics for doing designs, and
- they also specify how end-product instruction should look.

Thus in both a product and process sense, ID theories serve as guides to professional practice. Conceptually, ID theories are much closer to engineering than to science. They are about how to get something done, how to design a solution, not about how the world is. In that sense, they are really less theories and more models for action, for problem solving.

Such design theories may be based on a lot of hot air, or they may have some validity. What kind of knowledge base are these theories built on? Several forms of knowledge may contribute to an ID model, including:

- ***scientific*** knowledge of learning and related sciences
- ***craft*** knowledge of effective design, based more on teaching practices than on formal scientific research
- ***idiosyncratic*** knowledge about instruction unique to the ID profession, untested by formal research yet functionally important to ID practice.

Reigeluth (1983a) has outlined a prescriptive framework for embodying this knowledge. A series of rules are developed connecting existing conditions, desired outcomes, and recommended methods to instrumentally obtain those outcomes. For example, if your learners are new to a concept and you want them to learn it at an application level, then you might present a statement of the definition followed by examples and practice opportunities to classify new cases. An ID theory builds a collection of similar IF-THEN rules; designers are then supposed to apply those rules to their various situations.

This is a fairly technical view of design activity. Schön (1987), in fact, refers to exactly this type of thinking as *technical rationality*.

> From the perspective of technical rationality...a competent practitioner is always concerned with instrumental problems. She searches for the means best suited to the achievement of fixed, unambiguous ends...and her effectiveness is measured by her success in finding...the actions that produce the intended effects consistent with her objectives. In this view, professional competence consists in the application of theories and techniques derived from systematic, preferably scientific research to the solution of the instrumental problems of practice. (p. 33)

Schön's technical rationality looks a lot like Reigeluth's conditions–outcomes–methods framework. Schön does not deny that some problems encountered are routine ones that relate to the rules and concepts of the discipline. However, professionals go far beyond technical rationality when they encounter novel problems:

> There are also unfamiliar situations where the problem is not initially clear and there is no obvious fit between the characteristics of the situation and the available body of theories and techniques. It is common, in these types of situations, to speak of "thinking like a doctor"—or lawyer or manager [or instructional designer!]....
>
> We would recognize as a limiting case the situations in which it is possible to make a routine application of existing rules and procedures....Beyond these situations, familiar rules, theories, and techniques are put to work in concrete instances through the intermediary of an art that consists in a limited form of reflection-in-action. And beyond these, we would recognize cases of problematic diagnosis in which practitioners not only follow rules of inquiry but also sometimes respond to surprising findings by inventing new rules, on the spot. (Schön, 1987, p. 35)

Technical rationality suggests a clear demarcation between theory and practice, with categories of basic knowledge, applied knowledge, and practice. Theory is

what gets written in textbooks and professional journals, while practice tends to be mistrusted since practitioners never have the good sense to apply theory correctly. On the other hand, Schön's reflective practitioner model blurs the line between theory and research, suggesting that practitioners embody personal theories of practice, and often assume a kind of research stance toward their work (see also Winn, 1990). Schön makes clear the philosophical basis of his view of practice:

> Underlying this view of the practitioner's reflect-in-action is a *constructionist* view of the reality with which the practitioner deals—a view that leads us to see the practitioner as constructing situations of his practice, not only in the exercise of professional artistry but also in all other modes of professional competence....[O]ur perceptions, appreciations, and beliefs are rooted in worlds of our own making that we come to *accept* as reality. (Schön, 1987, p. 36)

In contrast,

> technical rationality rests on an *objectivist* view of the relation of the knowing practitioner to the reality he knows. On this view, facts are what they are, and the truth of beliefs is strictly testable by reference to them. All meaningful disagreements are resolvable, at least in principle, by reference to the facts. And professional knowledge rests on a foundation of facts. (p. 36)

Thus Schön is setting certain conditions for a constructivist model of instructional design. If you buy into a constructivist idea of the world, learners become active creators of meaning (and teachers to others), and teachers are continual learners.

> Communities of practitioners are continually engaged in what Nelson Goodman (1978) calls "worldmaking." Through countless acts of attention and inattention, naming, sensemaking, boundary setting, and control, they make and maintain the worlds matched to their professional knowledge and know-how....When practitioners respond to the indeterminate zones of practice by holding a reflective conversation with the materials of their situations, they remake a part of their practice world and thereby reveal the usually tacit processes of worldmaking that underlie all of their practice. (Schön, 1987, p. 36)

I have cited Schön heavily because I am convinced that we need to rethink the roles of formal ID theory and the ID practitioner (see also Hoshmand & Polkinghorne, 1992). Schön's model is not complete—for example, he does not pursue the ethical/moral dimensions of professional decisionmaking in an institutional context. But his views serve as a valuable starting point for discussion.

The expert/novice literature within cognitive psychology reaches similar conclusions about the nature of expertise. Researchers have found that expertise is

- largely intuitive and inaccessible to direct reflection (e.g., Bloom, 1986)
- more pattern-matching than rule-following (Suchman, 1987, Bereiter, 1991)
- more qualitative than quantitative (White & Frederiksen, 1986)
- highly context- and domain-dependent (Brandt, 1991).

Such a view of expertise seems also to fit the field of ID. We know that professional designers are highly flexible and adaptive in applying their knowledge to working problems (Nelson & Orey, 1991; Thiagarajan, 1976; Nelson, Magliaro, & Sherman, 1988); moreover, their use of knowledge seems to differ significantly from formal theories (Tessmer & Wedman, 1992; Wedman & Tessmer, 1990). With this view of expertise, the precise role of traditional theory is left in question. If ID theories are not descriptive science, and not a set of rules to be unambiguously applied to problems, then what are they and what value do they have?

One possibility is that the recipes contained in ID theories may have some value to novice designers. R. Putnum (1991) found that when learning a complex subject, novices tend to grasp onto formulas and recipes to support initial performance, then chang their use of the recipes as they gained expertise. The main problem with this rationale, though, is that ID theories are not formulated as simple recipes; they are

not easy-to-use "hooks" into a subject. Rather, ID theories are typically represented as formal, technical-sounding systems with extensive jargon, big words, and acronyms. The ID theory papers I have read are anything but a support to novices. ID theories are written as though they were serious science; novices require another type of representation altogether to support their initial learning needs.

Another possibility is that ID theories are not really meant to be used by human designers in normal situations, but rather are best suited to computer-based training and automated instructional design. This possibility is much more promising, even though both Gagné and Merrill have denied the need for separate formulations of ID theory for computers and traditional media (Gagné, 1988; Merrill, 1988) . Of course, there is still the question of whether theorists can successfully represent design knowledge with computers. It may turn out that the IF-THEN rule approach to design may be unable to capture true design expertise. This is, however, an empirical question worthy of continued investigation.

In summary, ID theory, with its prescriptive orientation toward both procedure and product, lies in conceptual limbo. Its status remains unclear in light of cognitive/constructivist views on expertise and professional problem-solving. In spite of these difficulties, I believe that there can be such a thing as a constructivist theory of instruction. At the paper's conclusion, I recommend several changes to revitalize ID theory and its place within practice and within the discipline.

The Cooperative Metaphor

Ken Komaski, director of the EPIE Institute, raised an issue a few years ago that has continued to affect my views. Citing Buchanan's (1963) study of ancient Greek and medieval thought, Komaski suggested that technologies can be divided into two distinct groups:

> In the first group are the arts practiced on matter and on the many things and forces found in nature. These arts, such as sculpture, agriculture, hydrology, painting, carpentry, cooking, etc., are arts in which "the form in the artist's mind...could be impressed on the matter...which could be fashioned and formed [Buchanan, 1963]." [O]ur uses of all technologies have been—and continue to be—influenced by this view of "technology as a system of exploitation." (Komaski, 1987, p. 9; italics removed)

The exploitative technologies are contrasted by:

> those arts "practiced on human beings, who also have artistic capacities." In humans there are "natural processes which if left to themselves might accomplish their ends, but if aided by the professional would accomplish their ends more easily and more fully. Medicine and teaching were the frequently discussed examples of such arts. They were called cooperative arts because they were understood to be cooperating with rational natures." The physician who gains the cooperation and confidence of patients, and the teacher who gains the willing cooperation of students, are much more apt to end up with healthy patients and competent learners than those doctors and educators who fail to gain such cooperation. (Komaski, 1987, p. 9)

Komaski notes that "it is the *exploitative technologies*, with their undeniable and demonstrable efficiency and effectiveness, that have shaped our thinking about, and our practices of, all technologies—including those such as medicine and teaching that, presumably, function more effectively when practiced as *cooperative technologies*" (Komaski, 1987, pp. 9–10; see also Mumford's [1967] distinction between authoritarian and democratic technologies).

It would be an interesting exercise to classify various known educational technologies on the exploitative/cooperative continuum. I am afraid that traditional ID theories fall too neatly into the exploitative category, with attendant consequences. The despised factory model of schools has a close cousin in the machine model of ID. The content of current ID theories also belies this orientation. In Reigeluth's green book (Reigeluth, 1983b), only the Gagné chapter and Keller's ARCS chapter treat student attitudes in any lengthy way. ID's manipulative bent is ironic, given the recent emphasis on working with schools in restructuring initiatives (e.g., Banathy, 1991) and on cognitive apprenticeships (e.g., Wilson & Cole, 1991). We clearly need more cooperative metaphors and rhetoric in our ID literature.

Task/Content Analysis and the Nature of Knowledge

Does all learned (or taught) knowledge have to be pre-analyzed? Of course not. There is much learned within any instructional environment that goes far beyond the instructional objectives. Curriculum theorists and media critics have been making that point for years (Hidden curriculum reference; Hlynka & Belland, 1991). Yet ID theorists and practitioners give every indication that their method of slicing up the world is *the* method, and that the content resulting from their analysis is *the* content to be taught to students. More than anything else, this aspect of ID theories has troubled me (see Wilson & Cole, 1992 for a similar discussion).

Eisner (1988) puts the counter argument succinctly in an abstract to a paper:

> Knowledge is rooted in experience and requires a form for its representation. Since all forms of representation constrain what can be represented, they can only partially represent what we know. Forms of representation not only constrain representation, they limit what we seek. As a result, socialization in method is a process that shapes what we can know and influences what we value. At base, it is a political undertaking. (p. 15)

The conceptual schemes we apply to the world constrain that world. Similarly, the schemes instructional designers apply to content constrain and shape that content, necessarily distorting it to fit our preconceived notions. If by some chance the educational community were to agree on knowledge categories, then there might be some basis for using those consensual categories in content and task analyses. But educators do not agree. Alexander, Schallert, and Hare (1991), in a recent review, found 25 distinct knowledge types cited in the educational literature on language and cognition. And that article was an attempt to simplify the problem!

If our knowledge categories are faulty (which they are), then how can we design adequate instruction? A short answer is, don't make the quality of your instruction rise or fall on the quality of your analysis. There is more to instructional design than analysis. Bunderson made essentially the same point years ago in his discussion of the "lexical loop" (Bunderson, Olsen, Gibbons, & Kearsley, 1981). The lexical loop refers to the parade of print-to-print translations we put content through as part of a traditional design process, beginning with needs and content analyses and ending in paper-based tests (see Table 2). As an alternative, Bunderson proposed a series of qualitative "work models" progressing in difficulty and fidelity to the target setting. These work models or learning environments are highly reminiscent of White and Frederiksen's (1986) progression of practice environments based on careful cognitive task analysis of mental models; I believe that such analyses remain highly relevant to the design of instruction, particularly multimedia products.

Knowledge of the Master	
The Lexical Loop	**Work Models**
Translation to goal statements through goal/job analysis.	Master performance is documented through multiple media.
Translation to objectives list through task analysis.	Work models are designed of progressively increasing difficulty. —Learning environments simulate real-life environments. —Students practice holistic as well as parts skills.
Translation to print-based tests through test item technologies.	—Authentic tools are available. —Info can be accessed through job aids, help systems, and other resources. —Coaching, mentoring, and peer consultation is available as needed.
Translation to print-based media using text-design principles.	Students complete work models 1...n.
Student expected to transfer text material into skills ot the master.	Student demonstrates master's knowledge/skill in real-life performance environment.
(Actually, negligible transfer occurs to everyday life.)	

Knowledge of the Master

Table 2. Two paths from mastery to mastery (derived from Bunderson, et al., 1981, p. 206).

The role I am advocating for analysis is fairly modest. Analysis provides an overall framework for instruction, and provides extra help on some tricky parts, such as identifying likely misconceptions or previous knowledge that may undercut students' efforts to understand the content. The role of the designer is then to design a series of experiences—interactions or environments or products—intended to help students learn effectively. Neither the instruction nor the assessment of learning can be as confidently dictated as they were thought to be in the past. But the important point to keep in mind is that the design role is not lost in such a revised system; the design still happens, only it's less analytical, more holistic, more reliant on the cooperation of teachers and materials and learners to generously fill in the gaps left gaping by the limitations of our analytical tools. Instruction thus construed becomes much more integrally connected to the context and the surrounding culture. ID thus becomes more truly *systemic* in the the sense that it is highly sensitive to the conditions of use.

In summary, no matter whose 2X3 scheme you use, the world doesn't always fit such neat epistemological categories. Force-fitting people's expertise into ID taxonomies sometimes can do more harm than good. My recommended alternative is not to throw away the taxonomies entirely, but simply to:

1. admit the tentativeness of any conceptual scheme applied to content
2. realize that no matter how thorough the task-analysis net, it doesn't come close to capturing true expertise;
3. realize that since content representation is so tentative, designed instruction should offer holistic, information-rich experiences, allowing opportunities for mastery of un-analyzed content;
4. always allow for a lack of fit between the conceptual scheme and any given content;
5. realize that the very points of lack of fit can be the most critical to understanding that content area;
6. always be on the lookout for those critical points of idiosyncratic content demands.

Viewed in such a way, content analysis is less a leveling exercise and more an exploration of the terrain, noting and even exploiting rough spots. Rules, verbal information, and other such categories cease to have such literal epistemological status, and become mere tools in the design process. The change is largely one of attitude and stance. I personally do not write behavioral, typed objectives anymore unless required by the sponsoring agency. I try not to teach each content type separately (i.e., verbage apart from skills). Rather, I do what Gagné and Merrill (1990) have advocated: I try and combine all the learning outcomes into problem-solving instruction. There is a variety of possible strategies to address this problem, ranging from conservative to radical. All, however, should be able to fit within a constructivistic ID framework.

The Mystery of Expertise

A constructivist view of knowledge leads to another dilemma central to the ID process:

Subject matter experts know the content best but often have least access to it.

Because expert knowledge gets automatized, conscious representation typically drops out of the picture.

The corollary is just as disturbing:

To go beyond routine mediocre rule-based ID, a designer needs to know content deeply.

Shulman (1987) talks about the many kinds of sophisticated knowledge required of teachers. In addition to knowing the content, they must know how to teach it. This typically does not come automatically, but only after years of teaching the same subject (Berliner, 1986). Designers who script instruction from a newly acquired, superficial content knowledge cannot be expected to find just the right analogy, just the right way of approaching a topic. They do have an advantage over the non-teaching expert in that their understanding of the subject is freshly acquired; that means they have greater access to strategies that worked for them. But this advantage applies only to initial learning levels: Once instruction moves to non-elementary tasks, the designer is on more wobbly ground and lacks the insight needed to create the *best* teaching methods (if such a thing indeed exists). Falling back on known design concepts is not the optimal design solution, but becomes a means of only resort in such situations.

Together, these two problems pose a formidable paradox for ID: The people who know the subject best often can't relate to the learner, while the designer, with a good general schema for teaching and a closer feel for the learner's needs, doesn't have

a feel for the subleties of the content and is thus left to deal in superficials.

The role of the knowledge engineer—the designer's counterpart in AI—is a subject of continuing debate (e.g., Winograd & Flores, 1986; Dreyfus & Dreyfus, 1986); thus I am surprised that the designer/SME relationship is not more controversial than it is. We should be asking the same tough questions of designers that we ask AI knowledge engineers: Where does the expertise really come from? What is lost in the translation? Are IF-THEN rules sufficient to characterize expertise, or do we need a neural network? Can expertise be digitally represented? How can we make use of a greater variety of representation forms in our designs?

The standard metaphor for the designer/SME relationship is *extraction*: The designer has good people skills, asks the right questions, pushes the right buttons, and presto!—out comes the expertise, on paper no less. But of course things cannot be so simple. The level of communication between SME and designer needs to move beyond superficialities; somewhere between the two of them there must occur a synthesis of meaning; the design process must be deeply collaborative for good design to occur. I personally don't know how this happens. It remains a mystery.

Instructional Strategies

ID needs a richer language, a deeper conceptual framework for classifying instructional strategies. While this is not the place for such an effort, I have merely sketched out in Table 3 a number of instructional strategies that seem to facilitate more active construction of meaning (see also Wilson & Cole, 1991).

Simulations
Strategy and role-playing games
Toolkits and phenomenaria
Multimedia learning environments
Intentional learning environments
Storytelling structures
Case studies
Socratic dialogues
Coaching and scaffolding
Learning by design
Learn by teaching
Group, cooperative, collaborative learning
Holistic psychotechnologies

Table 3. A sampling of alternative instructional strategies.

A defender of traditional ID could suggest that our present theory base already contains prescriptions for designing all of the above. I would only counter that each of the above strategies deserves its own mini-design model, and that many traditional design concepts seem only to get in the way. It seems ludicrous, for example, to discuss simulation design using terms such as "expository," "inquisitory," "synthesizer," and "summarizer." A new framework and accompanying language is needed.

Student Assessment

Shepard (1991) recently reported some interesting findings about psychometricians' beliefs. About half of those surveyed believe in close alignment of tests and instruction and careful, focused teaching of tested content. Shepard argues, however, that such beliefs correspond to a "behaviorist learning theory, which requires sequential mastery of constituent skills and explicit testing of each learning step"

(p. 2). She argues for a constructivist alternative that emphasizes more authentic methods of assessment such as interviewing, observations, and holistic task performances (see Perrone, 1991; Linn, Baker, & Dunbar, 1991).

Jonassen (1991a) takes what I consider to be a more radical stance towards assessment, extending Scriven's (1973) notion of goal-free program evaluation to the goal-free assessment of student outcomes.

> Constructivistic outcomes may be better judged by goal-free evaluation methodologies. If specific goals are known before the learning process begins, the learning process as well as the evaluation would be biased....Criterion-referenced instruction and evaluation are prototypic objectivist constructs and therefore not [sufficient] for objectivistic environments. (p. 29; change based on Jonassen, 1991b)

I take exception to Jonassen's position for reasons I discuss below, but I am ambivalent about the general issue of assessment. Surely ID theory makes assumptions that make some people feel uncomfortable, for example, that instruction is purposive and goal-directed, and that attainment of those goals can be assessed. I believe these assumptions can be wholly compatible with a constructivist philosophy; here I differ with Jonassen. And certainly, assessment need not go to the extreme of being goal-free. It seems that a key question to ask is, Does the test performance require all of the contextualized reasoning and performing that the target performance would require? (Frederiksen & Collins, 1989). The question is one of fidelity and validity, not of goal-directedness.

I do not have a problem with the idea of goal-directedness and measurement, but I do have a problem with how it is often done. A true mastery model with micro levels of assessment would only be appropriate with highly defined technical content; I believe such methods would rarely be appropriate in public schools, though somewhat more often in training settings. Instructional designers in both school and corporate settings feel the need for better assessment methods that can be more fully integrated into the performance and instructional systems. I have not sorted out all the issues; I raise the question because of its clear importance to the field and to society at large. I continue to believe that improved assessment methods can be developed that are more consistent with a constructivist framework.

Concluding Thoughts

The central issue of this paper is this: Is a constructivist theory of instructional design possible? and if so, What might be it be like? In typical backwards fashion, let me return to the question of the nature of ID theory by defining terms.

Instruction—teacher(s) and student(s) in interaction trying to learn something. Together they form an instructional subsystem within a larger system and community.

Design—"the process by which things are made...designers make representations of things to be built" (Schön, 1990, p. 110). Design is always done within constraints.

Constraints inherent in the design of instruction include:

a. Some situations don't even have teachers *per se*. Thus the teacher may be broadly thought of as the guiding agent, directing the learner toward accomplishing the goals of instruction. Learners themselves often function in the teacher role, as do instructional materials and programs.
b. Designers can usually exert more direct influence on the teacher side than on the learner side of the instructional system. At the same time, designers ignore considerations of the learner at their peril.

c. Designers can usually exert more direct influence over materials and tools than over the interaction between learner and teacher.
d. At the same time, the nature of the precise interaction between learner and teacher is at the heart of understanding instruction.

These constraints pose dilemmas for constructivist designers. As much as we may like to focus on individual learners' cognitions, often our access is extremely indirect and limited. This also helps to explain why ID is often a goal-based, stimulus-design oriented endeavor, working within a noisy system that is near chaos. It is no wonder that we get no respect; my response to critics who think we should get entirely out of such a messy business is, "If we didn't do it, somebody else would. Practitioners of ID need somewhere they can turn to, and our theories are as good as the next guy's." (I am actually serious about this.)

I have become convinced that a field is largely shaped by the central questions it puts for itself. In the case of ID, the questions are tough; there are no good answers, the best we can do is put forth some best guesses. We pay attention to stimulus design (a dirty word among cognitivists) because we have no choice. We prescribe general principles of message and interface design because those are aspects of the instructional system that lie somewhat within our power to influence. For good reasons we tend to get beat up by cognitivists, constructivists, and humanists; yes, it's a dirty job, but somebody's got to do it!

The next generation of ID theory needs to better fit the needs of the practitioner:

- ID theories need to be thoroughly grounded in a broad understanding of learning and instructional processes. That foundation needs to be continually evaluated and revised.
- We need more modest principles that designers can flexibly apply. These principles should be generic and principle-based in order to to be relevant to the wide variety of situations encountered in everyday practice.
- In addition to generic principles, we need specific heuristics for dealing with recurring problems and situations in ID practice. In particular, heuristics should be developed that are sensitive to:
  —*setting* (schools, business, museums, etc.)
  —*media* (computer, instructor-led, workbook, etc.)
  —*product type* (stand-alone product, program, system, etc.)
  —*resources* (time, money, constraints).
- ID theories need to reflect a view of ID as a profession. Designers need sophisticated schemas of design that go beyond the "technically rational" models presently available. Students should be encouraged to develop personal models of action through extensive practice in authentic settings with coaching and opportunities for reflection. (Note the theme of reflection running through students, teachers, and designers.)

Let me conclude by drawing a parallel with a couple of other disciplines, lest we think that we're alone in this chaotic science of design. Artificial intelligence right now is facing some of the same crises we are confronting. So is the field of human/computer interface design. Both of these fields have a strong tie to learning and cognitive psychology. Both rely heavily (at least in theory) on user testing and field validation. Old-time AI theorists presently are being challenged by connectionists, who believe that parallel processing via neural networks is a more promising way to go than symbolic manipulation of IF-THEN rules. The controversy goes beyond symbolic versus networked processing. A growing number of AI researchers have lost faith in traditional views of the representability of knowledge; the "situated" movement within AI goes so far as to deny that knowledge is a structure, and that memory is anything more than process (Clancey, 1991; Brooks, 1991). The field of interface design is going through similar growing pains, moving from a screen-design view of the field to a global, holistic view of the entire

human experience with computers (Laurel, 1990, 1991). This revised view of interface design has more to do with human activity than icons, buttons, and windows, more with dramatic metaphors, agents, and virtual worlds. And interface designers are moving away from controlled, linear design models toward rapid prototyping and participatory design (Bødker & Grønbaek, 1991).

I don't doubt that AI will be around in twenty years. Nor do I doubt that people will still be studying how computers and humans work together. The theories and concepts may change, but the basic questions are still there; they cannot be ignored. Likewise, ID will not go away; this is because the questions behind the field are genuine questions. The challenge for ID theorists is to continue to adjust our theories, or to replace them with better ones. The goal is to make our theories worthy of the questions.

Author Notes

This paper is based on a talk given at Brigham Young University, 4 December 1991. I wish to thank Peggy Cole, David Jonassen, and Lyn Taylor, Jane Birch, and Rob Boody for comments on an earlier draft.

References

Alexander, P. A., Schallert, D. L., & Hare, V. C. (1991). Coming to terms: How researchers in learning and literacy talk about knowledge. *Review of Educational Research, 61* (3), 315–343.

Banathy, B. H. *Systems design of education*. Englewood Cliffs NJ: Educational Technology Publications.

Bednar, A. K., Cunningham, D., Duffy, T. M., & Perry, J. D. (1991). Theory into practice: How do we link? In G. Anglin (Ed.), *Instructional technology* (pp. 88–101. Englewood CO: Libraries Unlimited.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing: The development of self, voice, and mind*. New York: Basic Books.

Bereiter, C. (1991, April). Implications of connectionism for thinking about rules. *Educational Researcher*, 10–16.

Berliner, D. C. (1986, August/September). In pursuit of the expert pedagogue. *Educational Researcher*, 5–13.

Bloom, B. S. (1986, February). Automaticity: The hands and feet of genius. *Educational Leadership*, 70–77.

Bødker, S., & Grønbaek, K. (1991). Cooperative prototyping: Users and designers in mutual activity. In S. Greenberg (Ed.), *Computer-supported cooperative work and groupware* (pp. 331–356). London: Academic Press.

Brandt, R. (1988–89, December/January). On learning research: A conversation with Lauren Resnick. *Educational Leadership*, 12–16.

Brooks, R. A. (1991). Intelligence without representation. *Artificial Intelligence, 47*, 139–159.

Bruner, J. S. (1964). Some theorems on instruction illustrated with reference to mathematics. In E. R. Hilgard (Ed.), *Theories of learning and instruction* (pp. 306–335). Chicago: National Society for the Study of Education (63rd yearbook).

Bruner, J. S. (1966). *Toward a theory of instruction*. Cambridge MA: The Belnap Press of Harvard University Press.

Bruner, J. S. (1986). *Actual minds, possible worlds*. Cambridge MA: Harvard University Press.

Buchanan, S. (1963). Technology as a system of exploitation. In C. F. Stover (Ed.),

The technological order: Proceedings of the Encyclopaedia Britannica conference (pp. 151–159). Detroit MI: Wayne State University Press.

Burton, R. R., & Brown, J. S. (1979). An investigation of computer coaching for informal learning activities. *International Journal of Man-Machine Studies, 11*, 5–24.

Bunderson, C. V., Gibbons, A. S., Olsen, J. B., & Kearsley, G. P. (1981). Work models: Beyond instructional objectives. *Instructional Science, 10*, 205-215.

Clancey, W. J. (1991). The frame of reference problem in AI. In K. vanLehn & A. Newell (Eds.), *Architectures for intelligence: The twenty-second Carnegie Symposium on Cognition*. Hillsdale NJ: Erlbaum.

Connelly, F. M., & Clandinin, D. J. (1990). Stories of experience and narrative inquiry. *Educational Researcher, 19* (4), 2–14.

Dreyfus, H. L. (1991). *Being-in-the-world*. Cambridge MA: MIT Press.

Dreyfus, H. L., & Dreyfus, S. E. (1986). *Mind over machine: The power of human intuition and expertise in the era of the computer*. New York: The Free Press.

Eisner, E. W. (1988). The primary of experience and the politics of method. *Educational Researcher, 17* (5), 15–20.

Faulconer, J. E., & Williams, R. N. (1990). Reconsidering psychology. In J. E. Faulconer & R. N. Williams (Eds.), *Reconsidering psychology: Perspectives from continental philosophy* (pp. 9–60). Pittsburgh PA: Duquesne University Press.

Frederiksen, J. R., & Collins, A. (1989, December). A systems approach to educational testing. *Educational Researcher*, 27–32.

Gagné, R. M. (1988, February). *Presidential session: A conversation on instructional design*. Paper presented at the meeting of the Association for Educational Communications and Technology, New Orleans. [Response to question from the audience.]

Gagné, R. M., & Merrill, M. D. (1990). Integrative goals for instructional design. *Educational Technology Research and Development, 38* (1), 23–30.

Goodman, N. (1978). *Ways of worldmaking*. Minneapolis MN: Hackett.

Goodman, N. (1984). *Of mind and other matters*. Cambridge MA: Harvard University Press.

Harel, I. (1991, April). *When mathematical ideas, programming knowledge, instructional design, and playful learning are intertwined: The Instructional Software Design Project*. Paper presented at the meeting of the American Educational Research Association, Chicago.

Harel, I, & Papert, S. (1990). Software design as a learning environment. *Interactive Learning Environments*, 1(1), 1–32.

Heideggar, M. (1984). *The metaphysical foundations of logic* (M. Heim, translator). Bloomington IN: Indiana University.

Hidi, S. (1990). Interest and its contribution as a mental resource for learning. *Review of Educational Research, 60* (4), 549–571.

Hlynka, D., & Belland, J. C. (Eds.). *Paradigms regained: The uses of illuminative, semiotic and post-modern criticism as modes of inquiry in educational technology*. Englewood Cliffs NJ: Educational Technology Publications.

Hoshman, L. T., & Polkinghorne, D. E. (1992). Redefining the science-practice relationship and professional training. *American Psychologist, 47* (1), 55–66.

House, E. R. (1991). Realism in research. *Educational Researcher, 20* (6), 2–9.

Johnson, M. (1987). *The body in the mind: The bodily basis of meaning, imagination, and reason*: Chicago: The University of Chicago Press.

Jonassen, D. H. (1991a, September). Evaluating constructivistic learning. *Educational Technology*, 28–33.

Jonassen, D. H. (1991b). Personal communication, November.

Komaski, P. K. (1987). *Educational technology: The closing-in or the opening-out*

of curriculum and instruction. Syracuse NY: ERIC Clearinghouse on Information Resources.
Komaski, P. K. (1989, March). *The future of educational technology*. Invited paper presented to the Special Interest Group on Instructional Technology, American Educational Research Association, San Francisco.
Lakoff, G. (1987). *Women, fire, and dangerous things*. Chicago: University of Chicago Press.
Lakoff, G., & Johnson, M. (1981). *Metaphors we live by*. Chicago: University of Chicago Press.
Laurel, B. (1991). *Computers as theatre*. Reading MA: Addison-Wesley.
Laurel, B. (Ed.). (1990). *The art of human-computer interface design*. Reading MA: Addison-Wesley.
Linn, R. L., Baker, E. L., & Dunbar, S. B. (1991, November). Complex, performance-based assessment: Expectations and validation criteria. *Educational Researcher*, 15–23.
Lumsdaine, A. A. (1961). Some conclusions concerning student responses and a science of instruction. In A. A. Lumsdaine (Ed.), *Student response in programmed instruction*. Publication 943, National Academy of Sciences. Washington D. C.: National Research Council.
May, R. (1975). *The courage to create*. New York: W. W. Norton.
Merrill, M. D. (1988, February). *Presidential session: A conversation on instructional design*. Paper presented at the meeting of the Association for Educational Communications and Technology, New Orleans. [Response to question from the audience.]
Molenda, M. (1991, September). A philosophical critique of the claims of "constructivism." *Educational Technology*, 44–48.
Mumford, L. (1967). *The myth of the machine: Technics and human development*. New York: Harcourt, Brace, & World.
Nelson, W. A., Magliaro, S., & Sherman, T. M. (1988). The intellectual content of instructional design. *Journal of Instructional Development, 11* (1), 29–35.
Nelson, W., A., & Orey, M. A. (1991, April). *Reconceptualizing the instructional design process: Lessons learned from cognitive science*. Paper presented at the annual meeting of the American Educational Research Association, Chicago.
Perrone, V. (Ed.). (1991). *Expanding student assessment*. Alexandria VA: Association for Curriculum Supervision and Development.
Polkinghorn, D. E. (1988). *Narrative knowing and the human sciences*. Albany NY: State University of New York Press.
Polkinghorne, D. E. (1990). Psychology after philosophy. In J. E. Faulconer & R. N. Williams (Eds.), *Reconsidering psychology: Perspectives from continental philosophy* (pp. 92–115). Pittsburgh PA: Duquesne University Press.
Putnum, H. (1990). *Realism with a human face*. Cambridge MA: Harvard University Press.
Putnum, R. W. (1991). Recipes and reflective learning: "What would prevent you from saying it that way?" In D. A. Schön (Ed.), *The reflective turn: Case studies in and on educational practice* (pp. 145–163). New York: Teachers College Press.
Reigeluth, C. M. (1983a). Instructional design: What is it and why is it? In C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status* (pp. 3–36). Hillsdale, NJ: Erlbaum.
Reigeluth, C. M. (Ed.). (1983b). *Instructional-design theories and models: An overview of their current status*. Hillsdale, NJ: Erlbaum.
Reigeluth, C. M., Merrill, M. D., Wilson, B. G., & Spiller, R. T. (1978, July). *Final report on the structural strategy diagnostic profile project*. A final report submitted to the Navy Personnel Research and Development Center, San Diego.
Resnick, L. B., & Klopfer, L. E. (Eds.). (1989). *Toward the thinking curriculum:*

Current cognitive research. Alexandria VA: Association for Supervision and Curriculum Development.
Rosch, E., Mervis, C., Gray, W., Johnson, D., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology, 8*, 382–349.
Rossett (1991). *Coaching successful performance*. Paper presented at the meeting of the Association for Educational Communications and Technology, Orlando.
Safire, W. (1991, November). If by whiskey... *Readers Digest*, 14.
Schön, D. A. (1987). *Educating the reflective practitioner*. San Francisco: Jossey-Bass.
Schön, D. A. (1990). The design process. In V. A. Howard (Ed.), *Varieties of thinking: Essays from Harvard's Philosophy of Education Research Center* (pp. 110–141). New York: Routledge.
Scriven, M. (1973). Goal free evaluation. In E. R. House (Ed.), *School evaluation*. Berkeley CA: McCutchan.
Shepard, L. A. (1991, October). Psychometricians' beliefs about learning. *Educational Researcher*, 2–16.
Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57* (1), 1–22.
Spiro, R. J., Feltovich, P. J., Coulson, R. L., & Anderson, D. K. (1989). Multiple analogies for complex concepts: antidotes for analogy-induced misconception in advanced knowledge acquisition. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning*. Cambridge UK: Cambridge University Press.
Spiro, R. J., & Jehng, J-C. (1990). Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter. In D. Nix & R. J. Spiro (Eds.), *Cognition, education, and multimedia: Exploring ideas in high technology* (pp. 163-205). Hillsdale, NJ: Erlbaum.
Suchman, L. A. (1987). *Plans and situated actions*. Cambridge: Cambridge University Press.
Suppe, F. (Ed.). (1977). *The structure of scientific theories* (2nd ed.). Urbana IL: University of Illinois Press.
Tessmer, M., & Wedman, J. (1992). *A survey of instructional-design practitioners*. Paper presented at the meeting of the Association for Educational Communications and Technology, Washington D.C.
Thiagarajan, S. (1976). Help, I am trapped inside an ID model! Alternatives to the systems approach. *NSPI Journal*, 10–11, 22.
Wedman, J., & Tessmer, M. (1990). Adapting instructional design to project circumstance: The layers of necessity model. *Educational Technology*, 48–52.
White, B. Y., & Frederiksen, J. R. (1986). *Progressions of quantitative models as a foundation for intelligent learning environments. Technical Report # 6277*, BBN.
Wilson, B. G., & Cole, P. (1991). A review of cognitive teaching models. *Educational Technology Reseach & Development, 39* (4), 47–63..
Wilson, B. G., & Cole, P. (1992). A critical review of elaboration theory. *Educational Technology Research & Development*, in press.
Winn, W. (1990). Some implications of cognitive theory for instructional design. *Instructional Science, 19*, 53–69.
Witherell, C., & Noddings, N. (Eds.). (1991). *Stories lives tell: Narrative and dialogue in education*. New York: Teachers College Press.
Winograd, T., & Flores, F. (1986). *Understanding computers and cognition: A new foundation for design*. Norwood NJ: Ablex.